Transfer of the SHOALS System Technology To the U .S. Army Corps of Engineers

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ABSTRACT

The Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS) system has completed its construction and field test phase of development. In order for the U.S. Army Corps of Engineers to realize the maximum return on its investment, a comprehensive program to transition and transfer the SHOALS system to operational status will be implemented. "The program has two goals: to demonstrate the technology and system to Districts and Divisions and to operate the system on a wide variety of project types. At the recommendation of the Program's Field Working Group, composed of District and Division representatives, the SHOALS system will be operated and maintained by a private hydrographic survey company, John E. Chance & Associates (JECA) of Lafayette, LA. Through competitive bid, JECA was awarded a contract to operate and maintain the SHOALS system, providing lidar survey services to all Districts and Divisions. The system will begin the transition process to a fully operational system during fiscal years 1995 and 1996 when it will be flown along the U.S. coasts including the Great Lakes and Gulf of Mexico. During these demonstrations, ancillary data will be collected to further characterize the systems operational envelope. This paper presents the SHOALS system's transition into operational use.

INTRODUCTION

The U .S. Army Corps of Engineers (USACE) will invest almost $11 million in development of the Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS) system (Figure 1), over 8 years. At the end of its development the system will be fully operational and integrated into use by the Corps. However, as with any new cutting-edge technology the transition to operational must be deliberate and focused in order to achieve the goals initially sought in development of the system. Much about the system must be learned and applied to optimize system performance, quantify operational characteristics, and most importantly, instill complete confidence in the user, USACE, about the system and technology. Since the SHOALS development program was initiated, an approach of involvement and information dissemination has been conducted. District and Divisions have provided representatives to the Field Working Group, an operational review group. Others in the Corps have been briefed at technical conferences such as the Corps' Survey and Mapping Conference, several Remote Sensing Conferences, many program reviews, and through newsletters and information bulletins, to begin transferring the technology. Over the next two fiscal years efforts to complete the transfer will be conducted with demonstrations on District navigation projects.

Figure 1 The SHOALS system mounted on a NOAA Aircraft Operations Center Bell 212 helicopter

To gain the full benefits of an airborne hydrographic survey system, we, the Corps, must change the way we look at conducting survey missions. Economic savings will be realized through grouping projects in a region then implementing a single regional survey. An economic study conducted as part of the SHOALS program shows that because of the system's speed and accuracy this approach is feasible and necessary to be cost effective.

This paper reviews the economic analysis and describes the transition phase of the SHOALS system from developmental to operational.

RESULTS OF ECONOMIC ANALYSIS

During the SHOALS Program's first phase, an economic analysis was performed by Gellman Research Associates, Inc. to determine if an airborne lidar bathymeter system could be operated at a cost savings to the government (Golaszewski et. al., 1990). The study considered the type of navigation projects operated and maintained by the Corps of Engineers and developed SHOALS system survey scenarios that optimized the system's capabilities and economic performance. Two primary findings of the study were:

> *The economic analysis was most sensitive to annual mission hours and system acquisition cost.*
>
> *The potential savings from an airborne lidar bathymeter system are greatest when a number of projects and mission are conducted together. This minimizes the influence of mobilization/demobilization on total costs.*

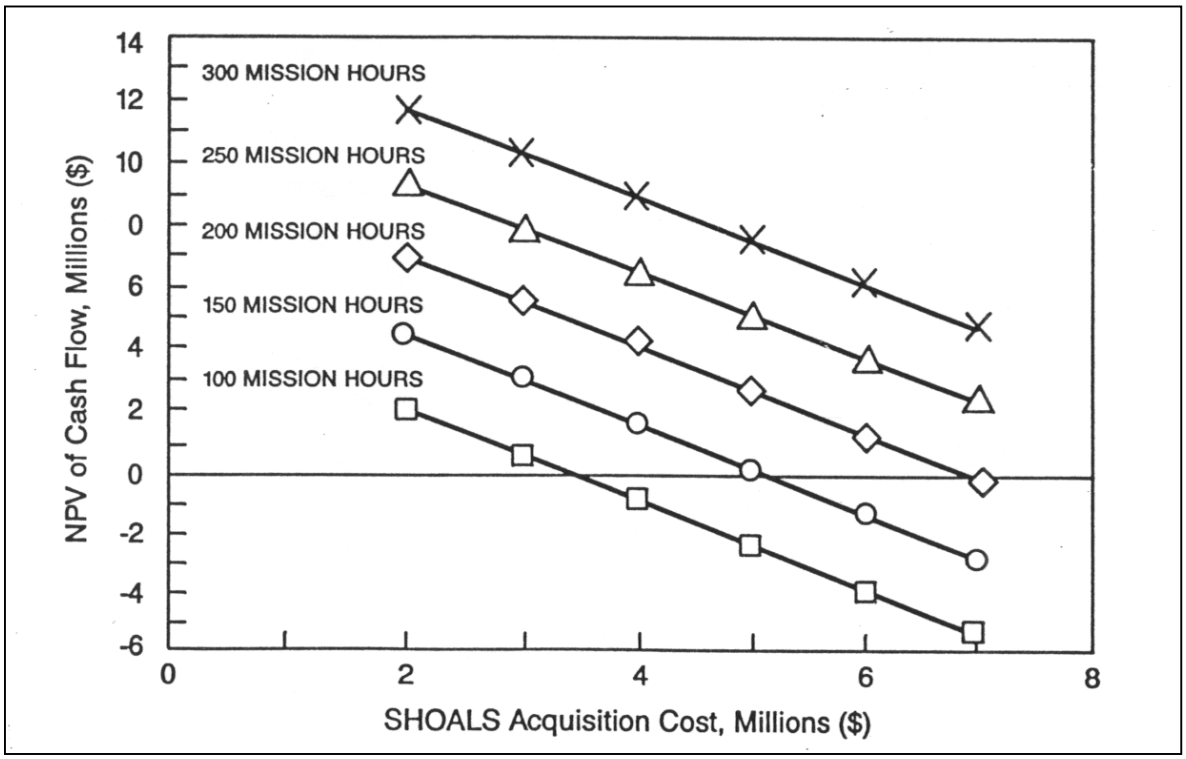

Figure 2 SHOALS Economic Summary

Figure 2 illustrates the first finding. Based on an acquisition cost of $5.5 million, the total number of mission hours required to produce a net present worth of zero at the end of d1e system's economic life was approximately 150 hours per year over 5 years. Mission hours included both flight time to and from a survey site and the time conducting the survey mission. Based on a questionnaire submitted to all Corps' Districts in 1988, approximately 25 percent of the Corps' navigation projects were estimated as surveyable using this technology, which equated to over 300 mission hours per year. This estimate was considered conservative because although developed for surveying navigation channels, the SHOALS system can conduct any hydrographic survey mission such as beach and nearshore surveys and storm damage assessment surveys that were not considered in the economic evaluation.

The second study finding is logical, but not commonly practiced. The daily cost of operating a helicopter, its pilots and maintenance crew, and the hydrographers is higher than the daily costs of a conventional hydrographic survey crew and boat. The cost effectiveness of the airborne system is realized from its ability to cover survey areas very rapidly. The SHOALS system can survey ten to one hundred times faster than a conventional vessel-based acoustic system giving the SHOALS system the capability to conduct a project survey in hours rather than days. To fully utilize the technology, projects must be combined and regions covered during a single SHOALS deployment.

At the request of the Mobile District, an estimate was prepared last spring to conduct over 450 square miles of hydrographic surveys south of Mobile Bay, using SHOALS. The estimated cost was about $1,200 per square mile. Using a state-of-the-art multibeam acoustic system would cost an estimated $5,000 per square mile. The cost savings are due to fewer days in the field (about 75 for the SHOALS and 300 for the fathometer system). Another example of efficiency

was demonstrated for the New York District in June 1994. Shinnecock and Moriches inlets were surveyed in one day, with a depth measurement made over a uniform grid every 12 ft apart. Once the two inlets were surveyed, the SHOALS system then surveyed the nearshore beach from approximately 3 ft to 30-ft-deep between the inlets, a distance of over 14 miles. The survey produced a depth measurement every 12 ft over the entire area, a total of about 10 square miles in 6 hours of surveying.

An example of a typical SHOALS mission was developed for the economic analysis. It has the system surveying five projects in the Miami, FL area including Lake Worth, Port Everglades, Bakers Haulover Inlet, Miami Harbor, and Miami Beach, then flying south and surveying San Juan Harbor, PR, and returning to Miami. There are a calculated total 160 nautical miles (nm) of surveying and an additional 2,092 nm of transiting to the survey sight (Golaszewski, et.al., 1990). The estimated cost of conducting this survey with a conventional acoustic system was $151,700. The estimated cost using the SHOALS system was $73,059, completing the survey mission in approximately 5 days. By combining multiple survey projects into a SHOALS survey mission, use of the SHOALS system is very economical.

GOVERNMENT OWNED - CONTRACTOR OPERATED

The Field Working Group (FWG) for the SHOALS Program has played an important role in development of the system. The Group is composed of 10 District and Division representatives, half the members are responsible for hydrographic survey data acquisition while the other half are data users. Their first responsibility was to ensure that the conceptual design of the airborne lidar system met the operational requirements of the Corps. This was accomplished by review of the conceptual design and several meetings with the SHOALS manufacturer. The group's second responsibility was to recommend how to transition the SHOALS system from developmental to operational, and fully capable of providing hydrographic survey support to the Corps of Engineers. Several FWG meetings dealt. with this topic and one meeting included a representative from the Canadian Hydrographic Service (CHS) who discussed how they utilized the Larsen 500, the first operational airborne lidar system in the world, developed for the CHS.

Several considerations were important in the FWG's recommendation to have the SHOALS a government owned -contractor operated system *(GO/CO).* They included the following:

> *The SHOALS system needs an -operational advocate- with desire, incentive, and opportunities to exercise the system and technology fully under a wide range of conditions nation-wide. The more the system is used, the quicker its full complement of operational characteristics will be defined, and the sooner it will become fully operational.*
>
> *The Waterways Experiment Station does not have the manpower, expertise, or mission to operate the SHOALS system. Housing the system in one District will severely limit its widespread use. (it is unlikely one District could support the entire Corps).*
>
> *The maximum economic and technological return to the Corps as a whole will be realized through quick, widespread application.*
>
> *A GO/CO system is the same approach used by Canadian Hydrographic Service (CHS) with Larsen 500 resulting in its successful operation.*

A competitive contractor selection process was initiated, which took 18 months to complete. The award went to John E. Chance and Associates of Lafayette, LA. The selection was based on five evaluation factors that each potential system operator had to show capability in. These factors were to show:

> *Demonstrated experience, expertise, and existing capabilities in hydrographic surveying of U.S. Army Corps of Engineers coastal navigation projects.*
>
> *Demonstrated experience and expertise in developing, operating, and up grading high-tech, state-of-the-art hydrographic survey systems and/or general scientific data acquisition systems.*
>
> *Demonstrated experience and expertise in satellite positioning.*
>
> *Ability to operate worldwide but particularly on coastlines within the United States including Alaska, Hawaii, and the U.S. Territories.*
>
> *Experience of personnel proposed.*

These selection criteria were designed to identify an existing hydrographic survey company, conducting surveys for the Districts, and fully capable of operating and maintaining a state-of-the-art system. The contractor is responsible for the complete operation and maintenance of the SHOALS system, providing technical support to the Corps, conducting up-grades to the system, conducting accurate hydrographic surveys and maintaining a high standard of quality control, and also providing all necessary administrative support.

John E. Chance and Associates (JECA), a member of the Fugro Group of Companies, was selected from a field of five bidders. JECA, with over 350 employees, conducts hydrographic surveying for the USACE with additional efforts in research and development on projects such as "on-the-fly" GPS positioning for the Topographic Engineering Center.

The company operates nation-wide and with other member companies from the Fugro Group, has the capability to operate worldwide. They have broad expertise in all aspects of hydrographic surveying including data processing, system development (such as the HI-MAP multi-beam vessel), and satellite positioning with GPS and Starfix II.

SHOALS PROGRAM PHASE III

Phase I of the SHOALS program was to develop an airborne lidar bathymeter conceptual design to determine if the technology was capable of meeting the USACE needs. Phase II consisted of the detailed design, construction, and initial field-testing. A third and last phase will be initiated in fiscal year 1995 to properly transition the SHOALS system to fully operational.
Phase Ill objectives address the long-term goals of the SHOALS development program; to transition the SHOALS system into Corps use, demonstrating the technology to he Corps, other Federal and State agencies, and private industry. This is expected to create interest in the manufacture of additional systems that could become available in a competitive service market.

At the conclusion of Phase ill, the system will be fully operational and ready to augment existing USACE hydrographic survey capabilities. The Phase III approach is to:

a) Demonstrate Lidar-based hydrographic survey technology to Districts and Divisions through utilization of the SHOALS system on Corps projects. The SHOALS system will collect hydrographic survey data on a project while the District collects ground truth fathometer-based hydrographic survey data. The two data sets will then be compared to demonstrate the SHOALS system's capabilities and accuracy for given projects and regions. Coordination with each District's survey schedule will be made to minimize demonstration costs.

b) Determine the SHOALS system's full operational capabilities. The SHOALS system was accepted by USACE from the manufacturer, Optech Inc., on 31 March 1994, following ten weeks field testing to evaluate system compliance with performance specifications (Lillycrop, et.al., 1994). The tests were conducted in Sarasota, FL, because the region has characteristically clear waters and mild environmental conditions, such as wave climate. The tests concentrated on evaluating the performance specifications under these very limited conditions. In order to fully characterize the SHO~ system and quantify its operational envelope the system must be flown over a wide range of water clarity, project types, and environmental conditions.

SHOALS demonstration missions will utilize District survey data for direct comparison to demonstrate accuracy and capability. Personnel from the U.S. Army Engineer Waterways Experiment Station (WES) will contact Districts to coordinate survey schedules and identify which projects will be used for comparison. Estimates of project surveyability will be made using data from the Secchi Depth data collection effort, consisting of measurements made by the Districts over the past four years. Once the survey data are collected, WES will have on-site capability to conduct survey comparisons, calculating volume differences and various statistical parameters between the two surveys.

During the comparison missions, ancillary field data needed to characterize environmental conditions will be collected. Information collected will be analyzed and used to optimize hardware settings (surface detection logic and optical filter settings) and software such as the depth detection algorithm (propagation induced bias. estimates and diffuse attenuation/depth relations) over these different conditions and regions.

Phase III survey missions will begin in fiscal year 1995, along the U.S. East coast and Great Lakes over a 3 month period and conclude in fiscal year 1996 along the U *.S.* West coast and Gulf of Mexico over another 3 month period. Phase Ill products will be operation and comparison of the SHOALS system on Corps projects, a report detailing these comparisons, a report detailing the characterization and optimization of the system, a report providing specifications and guidance for Districts and Divisions and utilize to obtain SHOALS surveys, and most importantly, a fully operational SHOALS system.

SHOALS SURVEYS

The SHOALS system is operated by John E. Chance and Associates for the USACE, flown on a Bell 212 helicopter provided by the National Oceanic and Atmospheric Administration (NOAA) Aircraft Operations Center. The depth extraction algorithm was, developed by the NOAA

National Ocean Service and SHOALS program management is provided through WES .As the system transitions from developmental to operational it will be available for survey work even before the end of Phase ill. Information about survey mission costs, scheduling, products and overall system capability can be obtained directly from wm. The primary information needed to evaluate a project is location, project dimensions (depth), and a nautical chart delineating the area to be surveyed. This will provide sufficient information to determine cost and overall survey requirements.

SUMMARY

Although not fully operational, the SHOALS system conducted limited surveys this summer for several Districts. The experience gained during these missions is forming the basis for planning Phase III surveys next fiscal year. Data collected reveal that the system has the potential to greatly enhance the Corps' hydrographic survey capabilities, helping to sustain the Corps position as a world leader in hydrographic survey technology.

ACKNOWLEDGEMENTS

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